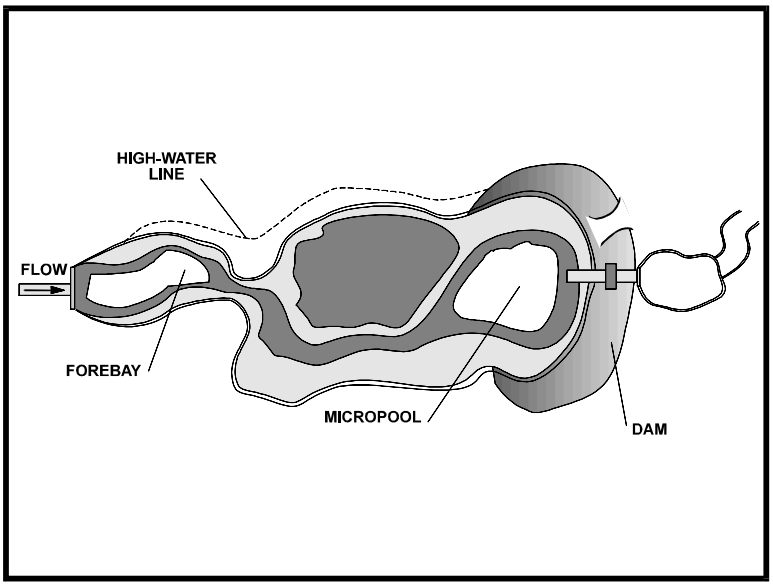
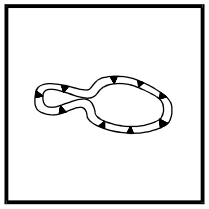
Infiltration Basin





BMP Objectives

- ● Sediment
- ● Oil and Grease
- ● Metals and Toxics
- ○ Nutrients
- ● Bacteria and Viruses

● Highly Effective
○ Low Effectiveness

Definition and Purpose

An infiltration basin is a device designed to remove pollutants from surface discharges by capturing the runoff volume from the water quality design storm and infiltrating it prior to the next significant storm event. The primary functions of infiltration basins are to remove pollutants from storm water runoff where soil conditions are suitable, and to recharge or replenish the ground water. In addition, infiltration basins can significantly reduce total annual surface runoff volume, which can reduce streambank erosion and other adverse impacts to stream habitats from transportation facility runoff.

Appropriate Applications

Consider infiltration basins for use when:

Runoff from the completed facility will discharge to significant areas of highly valuable habitat in which Federal or State listed aquatic resources have been identified; and

Caltrans runoff will constitute a substantial portion (more than 10 percent) of the total flows to such habitat

- Infiltration basins should be considered only when underlying soils are highly permeable and depth to groundwater is sufficient to allow infiltration and where groundwater pollution is not an anticipated concern.

- Infiltration basins are effective when a high level of particulate and dissolved pollutant removal is required. Pollutants are removed by filtering through the soil mantle. If properly designed, very little pollution travels more than 500 mm (20 in) below the basin bottom.

- Infiltration basins are usually most effective for drainage areas less than 2 ha (5 ac) where soil is porous, unless multiple basins are considered.

- Infiltration basins can be used in combination with detention basins for peak flow management. This type of facility is useful to provide flood control storage and significant water quality benefits by infiltrating the "first flush" (i.e., initial part of runoff where a large portion of the total pollutant load is concentrated in a relatively small portion of the total runoff volume).

- Typical highway applications include: within interchange areas; elongated basins in the median; or dedicated areas on the right-of-way.

Limitations

- Infiltration basins can be effectively used only where the soil is porous and can infiltrate the required quantity of storm water within 24 to 48 hours.

- Infiltration basins require a minimum invert to groundwater separation of 1.2 meters (4 ft.) using the seasonally high (wet-weather) groundwater elevation.

- Very coarse gravel soils provide low removal of dissolved pollutants which can increase risk of ground water contamination.

- Infiltration basins may not be suitable adjacent to drinking water wells, foundations, septic tanks, drain fields, unstable slopes, or on fill sites or steep slope areas due to potential seepage problems.

- Infiltration basins may not be appropriate where there is significant potential for hazardous chemical spills.

- Infiltration basins usually fail if they receive high sediment loads. Therefore, infiltration basins should not be used until upstream drainage area is stabilized.

- Maintenance needs of infiltration basins are high because frequent inspection is required.

- Infiltration basins require special care during construction to maintain permeability. Heavy equipment and machinery that will cause compaction and reduce permeability should not be allowed to travel over the area.

Design Guidance

Design of infiltration basins must be coordinated with the District Hydraulics Division. A typical resource used in the design of infiltration basins is HEC-22.

The physical suitability of the infiltration basin site should be evaluated for the following general design criteria:

- Infiltration basins shall be designed to capture, store and treat (infiltrate) the Water Quality Volume preferably as an off-line device. The Water Quality Volume is the volume of runoff produced by the equivalent of, at a

minimum, the treatment design storm event. Additional storage volume may be required for locations where an off-line device is infeasible due to physical or hydraulic constraints.

- Infiltration basins shall be located down gradient from the highway pavement to avoid infiltration to the pavement structural section and subgrade.

- Infiltration basins may require energy dissipation devices to minimize scour potential.

- Infiltration basins require an extensive geotechnical exploration to determine the subsurface profile and the hydraulic conductivity of the in situ soils. The exploration should perform field permeability tests in lieu of laboratory permeability tests. The presence of fine-grained materials can significantly reduce permeability.

- A minimum of one soils log should be required for each 465 m^2 (5,000 ft2) of infiltration basin area (plan view) and in no case less than three soils logs per basin. Each soils log should extend a minimum of 3 m (9 ft) in depth below the bottom of the proposed basin, in order to extend below the ground water level. Historical well records and geotechnical investigations must also be evaluated to establish potential ground water levels.

- Soil Suitability: Coarse soils with low ratio of organic materials should be used. Soils with 30 percent or greater clay content or 40 percent or greater silt/clay content should not be used. Infiltration basins should not utilize fill material nor be placed over fill soils, though fill material is acceptable for berms surrounding the basin.

- Depth of Water Table: The invert of infiltration basins should be located at least 1.2 m (4 ft) above the seasonally high (wet-weather) groundwater elevation.

- Infiltration basins shall have an overflow outlet to limit the risk of overtopping the device.

- Proximity to Drinking Water Wells, Septic Tanks, Drain Fields, Building Foundations: The proximity of infiltration basins to other structures and facilities must be taken into account due to constituents in storm water and possible disruption/damage to other structures.

    - Provide a minimum clearance of 30 m (100 ft) between infiltration basins and drinking water wells, septic tanks, drain fields, and springs used for public water supplies.

- Infiltration basins should be located at least 6 m (20 ft) downslope and 30 m (100 ft) upslope from building foundations.
- Consult state and local health services department's criteria and project geotechnical engineer for further requirements.

- Land Slope: Infiltration basins can be located on slopes of up to 15 percent. Use of infiltration basins on steeper grades increase the chance of water seepage from the subgrade to lower areas of the site and reduces the amount of water which actually infiltrates.

- Pre-construction soil infiltration rate should be between 7.6 mm/hr (0.3 in/hr) and 100 mm/hr (4 in/hr), as determined by the project materials/geotechnical engineer.

- The infiltration basin site should have a maximum clay content of 30 percent and a minimum cation exchange capacity of 5 meq, which shall be determined by the project geotechnical engineer.

- Bedrock, or an impervious soil layer, shall be no closer than 1.2 m (4 ft) from the invert of the basin.

- Upon completion of the initial excavation, the side slopes of the infiltration basin, in addition to any embankments and the downstream outlets, should be stabilized to prevent siltation of the basin. When all areas contributing runoff to the sediment basin have been stabilized, and after removal of all accumulated sediments, the excavation of the basin to finished grade should proceed. The basin inlet should be designed to help prevent erosion. Erosion should be controlled by installing outlet protection/velocity dissipation devices (See "Outlet Protection/Velocity Dissipation Devices" BMP in this Guide.)

- Impact on local ground water, including recharge potential and water quality, should be examined.

- Infiltration Basin Sizing: The degree of treatment achieved by an infiltration basin is a function of the volume of storm water that is captured and infiltrated over time. Determine the design capture volume required using guidance under "Volume" below. Using the infiltration rate of the soil for a saturated condition (as determined by the project geotechnical engineer), determine the area of the basin bottom to infiltrate the capture volume in 24 hours, i.e.

$$A_R = V \Big/ 24 \times I_{sat}$$

where A_R = basin infiltration area required, m^2
V = design storm volume, m^3
I_{sat} = Saturated soil infiltration rate, m/hr
24 = Required time for the basin to empty, hrs

- Infiltration/retention times longer than 48 hours should not be considered to minimize the potential for mosquito breeding.

- Incorporate bypass or overflow for large events or build detention storage on top of the infiltration basin.

- Volume: Caltrans has adopted a maximum design goal of sizing detention basins to capture the entire runoff from a treatment design storm event (water quality design storm). Determine the treatment design storm event for either the closest rain gauge to the project site, or the average of the closest 2-3 gauges, particularly where there is a significant elevation difference between the closest gauge and the project site. The runoff produced by this storm based upon the characteristics of the project drainage area after completion of the project should then be calculated and the resulting volume used as a maximum design target.

The basic data requirements for a design analysis are:

  - the inflow peak discharge and hydrograph;
  - the (allowable) infiltration rate; and
  - the basin stage-storage relationship

The design process consists of establishing the inflow/storage/outflow relationship and adjusting the storage volume and outflow characteristics until the design objectives are met. In most cases, the inflow is fixed by upstream conditions, and the outflow is fixed by the design goals. The purpose of the analysis then is to determine the appropriate basin type, storage volume and outlet configuration. In many cases for roadway drainage design, the storage volume and basin type may be fixed, and the analysis determines the size of the outlet. Infiltration basins with volumes smaller than that which can store treatment design storm event may be considered under the following circumstances:

(1) Sufficient right-of-way is not available, or cannot be feasibly obtained to accommodate the volume.

(2) A site-specific MEP analysis is conducted in consultation with Headquarters Environmental Program staff.

Under the above circumstances, the minimum storage volume recommended is that which would capture at least 80 percent of all runoff from the project drainage area.

Other water quality capture volumes which would allow capture of greater than 80 percent of all runoff up to the treatment design storm event can be considered if right-of-way is available or if the site specific analysis indicates a greater level of capture is justified based upon an MEP analysis.

- Dedicated access to the basin bottom should be provided for maintenance vehicles.

- Basins may be lined with a 150 mm (6 in) to 300 mm (12 in) layer of filter material such as coarse sand to prevent the buildup of impervious deposits on the natural soil surface. To increase the permeability of clayey soils, a 150 mm (6 in) layer of coarse organic material may be specified; but trying to increase permeability is not recommended.

- If possible, the infiltration basin sides and bottom should be stabilized. Stabilizing with vegetation or non-vegetative measures on the sides of the basin minimizes erosion and controls dust; whereas the bottom of the basin is vegetated to reduce tendency to clog with fine solids. Whenever possible, native vegetation that requires less intensive maintenance and is less likely to become a nuisance should be used. The planting design should consider access to high maintenance areas such as inlet and outlet structures. Also, a stabilized buffer strip at least 6 m (20 ft) wide should be provided around the basin to protect against erosion and sloughing.

Special Construction Considerations

- Special precautions must be taken to the work sequence, techniques, and the equipment employed to protect the natural infiltration rate. Light equipment and construction procedures that minimize compaction should be used. The basin area should be flagged off while heavy equipment is in the area.

- Storm water should not be allowed to enter the infiltration basin until all construction is completed and the contributing drainage area to the basin is adequately stabilized. If this prohibition is not feasible in particular situations, do not excavate the facility to the final grade until after all construction is complete upstream.

- If native soils are very pervious, incorporate materials into confining levee to control seepage.

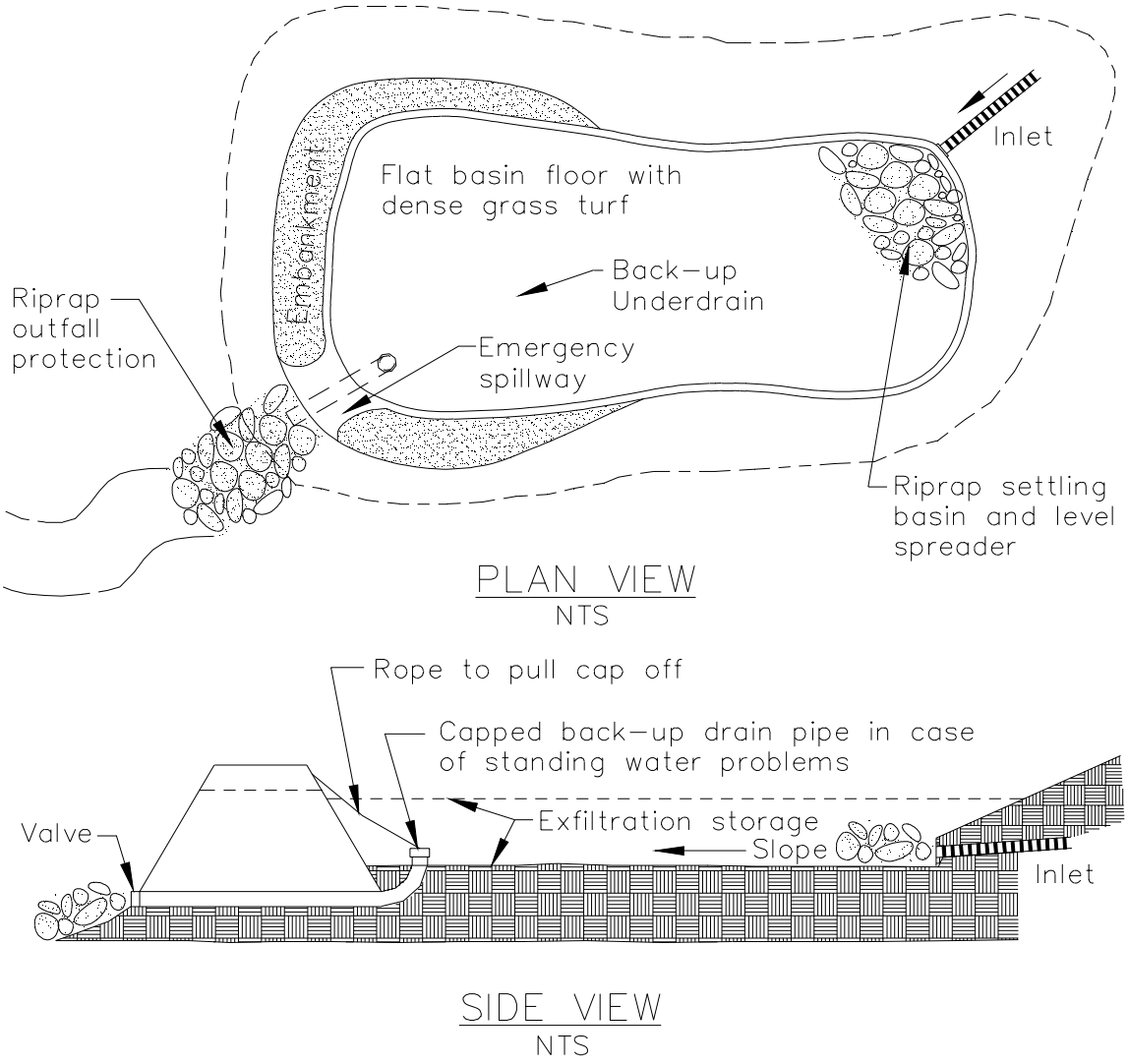
Maintenance and Inspection

The primary objective of maintenance/inspection activities is to ensure that the infiltration facility continues to perform as designed and to substantially lengthen the required time interval between major rehabilitation.

- Side slopes should be maintained as needed to promote dense vegetative cover with extensive root growth which enhances infiltration though the slope surface, prevents erosion and consequent sedimentation of the basin floor, and prevents invasive weed growth.

References

- Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22 – HEC22, U.S. Department of Transportation, Federal Highway Administration, 1996. Publication No. FHWA-SA-96-078
- Retention, Detention and Overland Flow for Pollutant Removal from Highway Stormwater Runoff. Volume 2. Design Guidelines. U.S. Department of Transportation, Federal Highway Administration, 1996. Publication No. FHWA-SA-96-096.
- Urban Runoff Quality Management, ASCE/WEF, 1998
- Caltrans Highway Design Manual, Chapter 810.



NOTE:

1. An infiltration basin can also be excavated typically 1.0 m to 3.6 m as long as the bottom of the basin is 1.0 m above high seasonal water table.

Adapted from: After Schueler (1987)
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FIGURE 1 – INFILTRATION BASIN SCHEMATIC